Objects Tracking Techniques

And their applications in modern security systems

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***Abstract*—In the recent years a lot of security systems have started to use object tracking techniques to increase their ability to detect any security related issues. In addition to that, a lot of modern security systems have the ability to act upon the received scene or situation not only just detect a security problem. This problem will discuss how object tracking is being used in modern security systems and how they detect any security issues. This paper also will discuss some of the cameras that are used is such systems to give a complete picture of the whole system.**

***Keywords*—Image Processing, Objects Tracking, Objects Classification, Static Cameras, multisensor security systems.**

I. Introduction

Object tracking is the process of locating a moving object over time using a camera. There a lot of applications or uses for object tracking such that: security and surveillance, augmented reality, traffic control, medical imaging, human-computer interaction, and video editing. Object tracking can be very time consuming because of the amount of data that is contained in video. Object tracking is often used with an object recognition technique for tracking to only track the targeted objects.

The objective of object tracking is to associate target object after detection in consecutive video frames. This detection and association can be very difficult if the object is moving faster than the frame rate of the camera that is used in the detection. Another difficulty may be added to the process if the object is changing orientation over time.

II. Methodology

In any security system, the regular architecture of object tracking and classification is used to detect the security situations and to act upon that.

The three main steps in such systems are like the following: motion segmentation, object tracking, and object tracking. These steps are described as follows.

A. *Motion Segmentation*

In the motion segmentation step, the pixels of each moving object are detected. Generally, the motion segmentation consists of background subtraction and foreground pixel segmentation. Frame differencing is an easy and common approach to do so. Using a median filter is also a common way of dealing with motion segmentation.

B. *Object Tracking*

After the background subtraction, objects are tracked. This step is the most important and the most error prone component of the whole system. Problems occur in many situations like the targeted object touch, or when they intersect with each other, or when they enter or leave the image. There are a lot of algorithms that can be introduced to solve such problem such as: CONDENSATION [1] method to track objects. This problem is not completely solved because efficient algorithms are very time consuming and very expensive in terms of processing and memory used, for example: model based algorithms are computationally more expensive because of the large number of parameters.

C. *Object Classification*

In object classification, the object type is detected and is being classified to 3D moving objects and 2D images. There are a lot of object to distinguish humans from vehicles, and there are other algorithms to distinguish cars from vans from bikes. Other algorithms are used to detect people groups. Algorithms that are used have two different types, whether they need to be trained before working or not.[1]

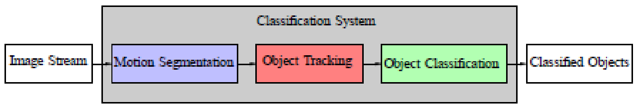

Figure 1. Common object classification system[1]

In modern security systems, popular and widely-used concepts of perimeter protection with double fence and zone sensors supported by area illumination and daylight visual cameras are now replaced by multi-sensor platforms. This is not the only way to implement security systems and to use object tracking in it. A lot of security systems are still using a

static camera to detect motion and send the video stream to the processing unit to detect any security problem in the area.

Efficiency of the system operator can be enhanced by enabling automatic detection of intruders using different detection methods.

III. Concept Of Security Systems

A. *Using a static camera*

The goal of the tracking is to establish correspondence between objects across frames. Robust classification of moving objects is difficult if tracking is inaccurate, this leads a decrease in the security system efficiency and performance.[1]

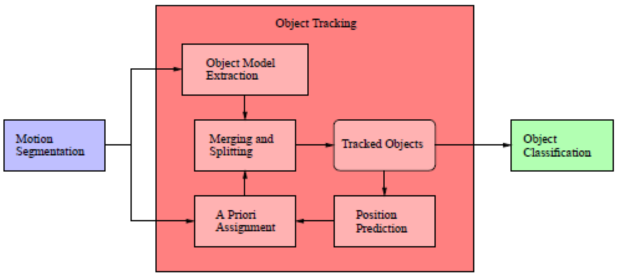

Figure 2. Flow diagram of the multiple object tracking algorithm.[1]

Object tracking using a static camera is simple; we just send the frames stream from the camera to the processing unit to do the three main steps mentioned above. This is the simplest way to implement a security system.

B. *Using a multi-sensor plaform*

Another way to implement a security system which is more expensive and more effective is to use a multi-sensor platform for objects tracking and classification. The following figure shows the main components of a multi-sensor platform based security system.[2]

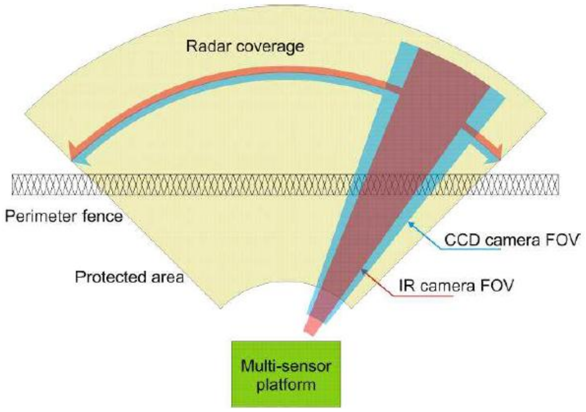

Figure 3. Observation areas of a multi-sensor platform security system.[2]

A complete multi-sensor unit is mounted on height to provide visibility to all sensors. A model of sensor carrier platform is presented in the following figure.

Figure 4. Design of the multi-sensor platform.[2]

The tracking algorithm is performed by separate computing module. Automatic tracking module ensures that the intruder won't be lost from the sight of the camera.

IV. Gradient SSD Algorithm

Multi-sensor security system is expected to have fast guaranteed reaction time; therefore it can be treated as a real-time system.

A. *Radar Detection*

Determine Object Localization "its Localization data ".

B. *Camera Visual Detection*

- Object Definition:

Object Parameter and its fundamental parameters. In this concept of multi-sensor platform a fixed size of average human was used.

- Tracking Algorithm Can be Applied:

Target feature-tracking

Mean-Shift algorithm: Inefficient when the tracked object covered small number of pixels.

- Sum-of-Squared-Differences (SSD) gradient algorithm:

Modified version of SSD algorithm was adopted to perform the tracking task in a security system.

Gradient SSD algorithm analyzes the differences between two consecutive frames to find the target object. The target movement is estimated by calculating spatial and temporal gradients.

C. *Advantages of using SSD gradient Algorithm*

A modification of Sum-of-Squared-Differences algorithm is proposed to improve tracking efficiency of small objects in infra-red image sequences.

The reason to use SSD algorithm is its better performance in tracking small objects, than in model based tracking algorithms.

However traditional Sum-of-Squared-Differences (SSD) algorithm is sensitive to partial or full occlusions, background clutter and changes in object appearance. To increase immunity

to this kind of noises the modification in model update procedure was developed.

The experimental results illustrate that the proposed modification to SSD algorithm can improve overall algorithm performance in infrared operation.

D. *Algorithm explaination*

First:

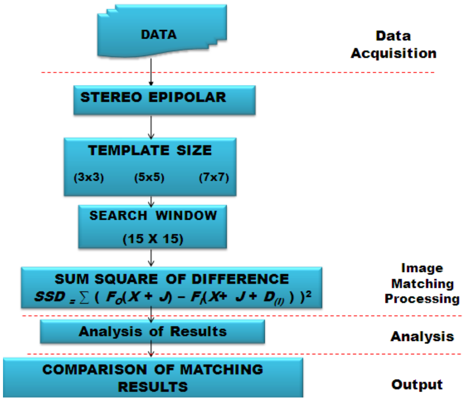

Figure 5. Block diagram of SDD matching procedures.

Stereo epipolar:

Stereo epipolar is generated to create a parallel line to ensure that point in left image is corresponding to the same point in the right image.

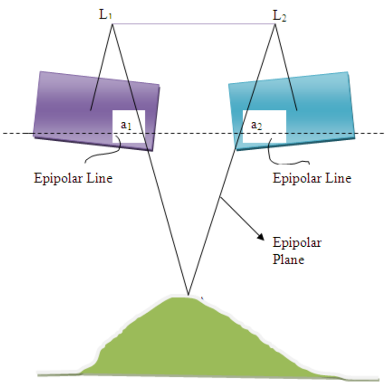

Figure 6. Epipolar plane and lines (Edward et al., 2001).

If one point on epipolar line in the left image is projected to the ground, the corresponding point in the right image should intersect on the same location on epipolar plane (Figure 6) (Edward et al., 2001).

Template Size:

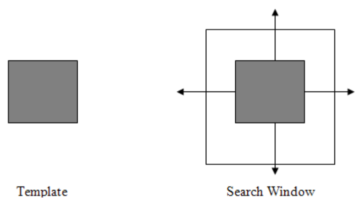

Figure 7. Moving template in search window.

E. *Sum of square difference matching algorithm*

It's matching technique where matching was done pixel-by-pixel or in other word, pixel-based matching (Figure 7). The concept of 'sum of square difference matching algorithm' is implemented left and right images (Figure 6).

A template with suitable size was moved in the search window to locate and match its conjugate points.

The size of the searching window must be larger than the template window (Sun, 2002). Figure 7 shows that the template with suitable size must be smaller than the size of the search window (for example, template of 3 × 3 and search window of 7 × 7 pixels and lines).

To obtain best correlation value, rectification of the images must be at high accuracy (Sun, 2002). The 'sum square of the difference' range is between 0 until 1. If the value was 1, it indicates that the difference between the pixels is high.

Therefore, the least value of SSD indicates less difference between the 2 pixels and indicates a better match. The equation for SSD matching algorithm can be expressed as:

$$SSD = \sum \left(fo(x + j) - fi(x + j + d(i)) \right)^2$$

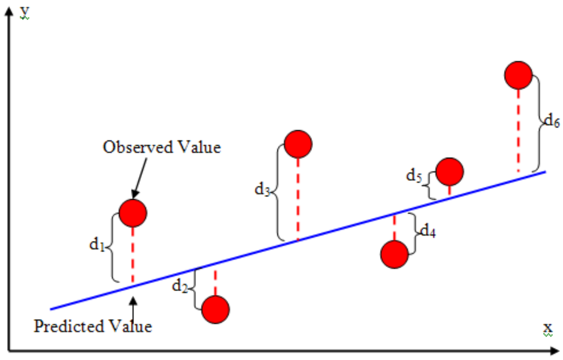

Figure 8. Determine best fit of data points.

The matching of pixels could be expressed and be calculated to determine the best fit so that matching can be more precise. Points are tested to determine the best fit which must obtain the least or minimum values to indicate the points have been strongly matched.

(Figure 8) shows that the relationship of points could be well explained. The closer the points to the line, the fit of the matched points were stronger and better prediction could be obtained. Compared to points that were away from the line, matches were not perfect. The residual error could be calculated by using the equation stated:

$$r = (P - P')$$

Where r is residual error, P is observed points (that is seed points in image 1) and P' is tested points (seed points in image 2). The calculation of the residual error is done to every matched pixel to determine the fit.

V. EXPERIMENTAL RESULTS

The following is some experimental results of using both techniques (static camera and multi-sensor platforms).

The experimental results mentioned here are taken from two different research papers [1] [2] and was not carried out by the team members.

A. *Using a static camera*

Three different scenes are chosen to represent the tracking algorithm; these figures show a successful objects detection and tracking; they are shown in the following figures.[1]

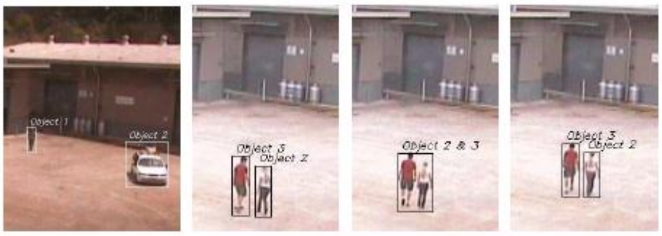

Figure 9. Multiple object tracking (left). Merging and splitting of two people in a scene (right).[1]

Figure 10. Crossing of two people in a scene.[1]

The following figures show a successful object classification of the given scene. They show how the algorithm used efficiently differentiated between a vehicle and a person.

Further tests have shown that classification system can achieve a frame rate up to 33-50 f ps.[1]

Figure 11. First scene: Person and car.[1]

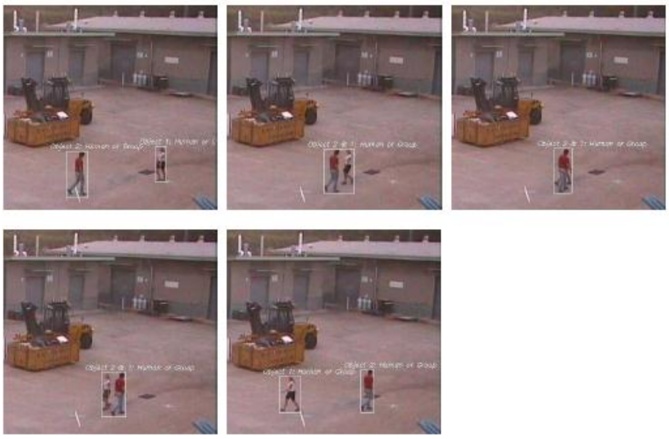

Figure 12. Second sce Figure 8. Second scene:

B. *Using a multi-sensor plaform*

The following figures show the results of object tracking using 2 algorithms (SSD and modified SSD).[2]

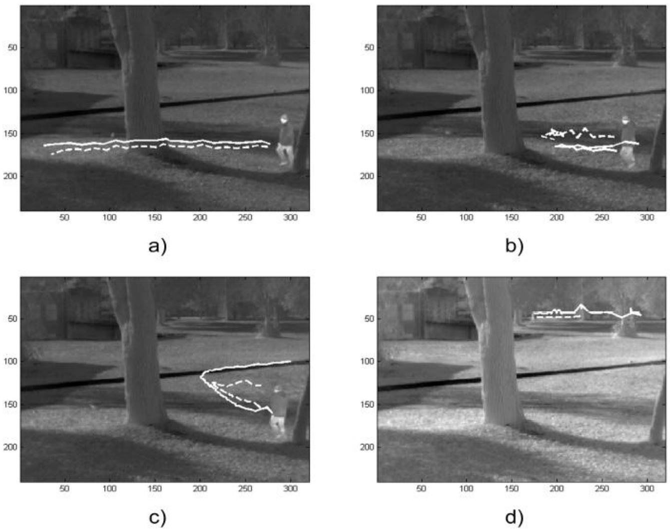

Figure 13. Results of tracking using traditional SSD algorithm (dashed line) and modified SSD algorithm (solid line).[2]

VI. RULE OF EACH TEAM MEMBER

A. *Abdel Rahman Samy El-Tamawy*

- Gather information about the chosen topic.
- Gather materials and papers regarding to help in making this paper.
- Attend both online and offline meetings to discuss and the project progress and phase.

B. *Amira Shawky*

- Gather information about the chosen topic.
- Search for the paper format that will be used.
- Gather materials and papers regarding to help in making this paper.
- Attend both online and offline meetings to discuss and the project progress and phase.
- Prepare the presentation material.

C. *Islam Alaa El-Din Mustafa Ali*

- Gather information about the chosen topic.
- Gather materials and papers regarding to help in making this paper.
- Attend both online and offline meetings to discuss and the project progress and phase.
- Integrate all team members' work in a research paper that follows to IEEE 2-columns format.

D. *Radwa Ashraf*

- Gather information about the chosen topic.

Gather materials and papers regarding to help in making this paper.

- Attend both online and offline meetings to discuss and the project progress and phase.

- Rehearse for the presentation as she will be the presenter in our topic presentation.

VII. Conclusion

After going through the different types of object tracking techniques that are used in security systems, one can conclude that object tracking has become an essential part of any security system that ensures effective performance.

In addition to that we have shown that object tracking is the most essential part of the whole security system because if the tracking is not accurate, the classification will be very difficult.

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